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OPERATIONAL CAPABILITIES OF COMMUNITY
FALLOUT SHELTER SYSTEMS

FINAL REPORT

William D. Shontz

April 1963

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Office of Civil Defense
Department of Defense

Contract No. OCD-OS-62-170

Dr. Leslie J. Briggs,
Principal Investigator

Mr. Fred Carr,
Project Coordinator

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Prepared by:

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Submitted by:

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This Final Report and its accompanying working documents, the Evaluation Instrument, Instruction Manual for the Evaluation Instrument, and Workbook For Use By Local Civil Defense Officials, have been reviewed in the Office of Civil Defense and approved for publication and limited distribution for purposes of OCD research, shelter planning, and guidance material development. Contents of these documents do not necessarily reflect the views and policies of the Office of Civil Defense.

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ABSTRACT

Two working documents for Office of Civil Defense use in producing guidance materials were prepared. They represent proposed approaches to guidance and evaluation documents for use in developing community shelter systems.

SUMMARY

Purpose

The primary purpose of this study was to develop an evaluation instrument which could be used to assess the operational capabilities of community fallout shelter systems. A secondary purpose was to translate the basic data used in constructing the evaluation instrument into guidance material useful to local civil defense planners.

Approach

Information on the characteristics of community shelter systems was derived through literature review, interviews with knowledgeable civil defense officials, and the systematic consideration of the gross tasks involved in system development, maintenance, and operation. From these basic data, 487 characteristics (hereafter referred to as plan factors) were written up as separate items in an evaluation instrument. An estimate of the importance of each plan factor was made by a group of thirteen raters. These judgments served as the basis for developing item weights. The item weights were subsequently incorporated into a scoring method for the instrument. The evaluation instrument was then applied to two sets of plans for community shelter systems.

The guidance material for local civil defense planners was prepared in workbook form. A brief discussion of each plan factor was written for each plan factor. Accompanying each such discussion was a "decision" statement paraphrasing the essential aspects of the factor as they would apply to a shelter system. Also, space was left for including comments regarding specific shelters within a system.

Results

1. The evaluation instrument which was developed proved capable of assessing the strong and weak points of plans for community shelter systems.

2. No particular difficulties were encountered in applying the instrument, or scoring the results of the evaluations.
3. No system characteristics appeared in the planning documents which were not adequately covered by plan factors in the instrument.
4. The guidance material document which was prepared presents an integrated source of information applicable to the development of a community shelter system.

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A GENERAL OVER-VIEW OF THE STUDY

Background

Positive action toward a dynamic national shelter capability is now being taken by the Federal government in the form of the National Fallout Shelter Marking and Stocking program. In addition, a few communities throughout the country have considered how a nuclear attack would affect them, and to varying degrees they have initiated planning activities oriented towards their own protective needs. It is expected that as more shelter space is designated (or developed) and stocked during the course of the marking and stocking program, more communities will begin to plan intensively and to act to provide protection from nuclear attack for their entire populations.

Whether a community elects to designate and modify existing buildings as shelters, or to construct shelters, there must be a well-coordinated and controlled system of shelters capable of protecting and sustaining the entire population of the community. For the purposes of this study, the objective of such a system may be stated as follows: "The purpose of a community shelter program is to protect the people of that community by preserving their respective capacities to a degree which will enable them to survive an enemy attack and return to near normal capacity for productivity in the shortest possible time." The effectiveness of a community shelter system in accomplishing this objective will depend to a great extent upon how well it can function as a system.

The term system, as used in this study, is analogous to its use in reference to a weapon system. Developing, operating, and maintaining a system involves very similar steps regardless of the nature of that system. For example:

1. System objectives must be determined.
2. Plans must be formulated for the achievement of these objectives.
3. There must be a developmental period.
4. The operational capabilities of the system must be evaluated to insure that it can, in fact, accomplish its objectives.
5. Once a system is operational, logistic, maintenance and management requirements must be met throughout the life of the system.

The system approach to developing a community shelter program is the concept on which work on this project is based. All research products of the project are aimed at enhancing the operational capability of community fallout shelter systems.

Purpose

The primary purpose of this study has been to develop an evaluation instrument which could be used to assess the operational capability of community fallout shelter systems. A secondary purpose has been to bring together, under one cover, information regarding the characteristics of an effective shelter system. This information is presented in a form which local civil defense personnel may conveniently follow when developing their plans.

It was originally planned that a central purpose of this study would be to utilize the evaluation instrument to be developed to appraise several representative community plans for using community shelter facilities developed to date under the national shelter program, including the Government-sponsored prototype shelter construction program. However, it became apparent very early in the contract period that civil defense planning and shelter construction at the community level were not sufficiently developed to permit full-scale evaluations. Where prototype shelters were under construction, no comprehensive plans for their use or integration into a community shelter system were available. Conversely, a few communities had accomplished some preliminary planning toward a community shelter system but had no actual shelter facilities.

In view of the situation, a shift in emphasis and consequent realignment of the contemplated research was suggested and subsequently approved. This revised plan called for (1) development of a more refined evaluation instrument having broader scope and longer usefulness than contemplated for the instrument conceived initially, and (2) preparation of an additional document to consist of information gathered during the development of the evaluation instrument and to be packaged in such a way as to have instructional value for local civil defense planners.

Research Products

Evaluation Instrument. The completed Evaluation Instrument contained 487 separate plan factor items. Each plan factor represented a characteristic or aspect of a community shelter system. Plan factor items were organized into 33 subject-matter categories within the Evaluation Instrument. This grouping of plan factors by subject-matter categories (and in some cases subcategories) served to provide a classification system whereby the user could readily locate a particular plan factor. It also provided a basis for summarizing the results of an evaluation in terms of major system functions such as Shelter Management and Radiological Defense.

In using the Evaluation Instrument, the evaluator must determine whether or not each plan factor has been, or will be, provided for in planning and developing the shelter system. For each plan factor, an all or none decision thus must be made. Although it would be desirable to obtain a more precise rating for each plan factor in accordance with the degree of adequacy reached in the plan being evaluated, little or no objective data are available at this time for use in making such precise discriminations. However, when data are available to indicate the minimal degree of adequacy in planning required to give credit for the item, such data are identified under the plan factor in the Evaluation Instrument; these data are labelled "STANDARD" in each instance, to show that the data will assist the evaluator in making the required yes or no decision.

A scoring method was developed for the Evaluation Instrument which would provide quantitative estimates of the operational capabilities of the shelter systems evaluated. For each plan factor item, the Evaluation Instrument shows the weighted score assigned to the item; this score corresponds with the judged importance of the item to system effectiveness, as determined by a group of judges.

The Evaluation Instrument is intended as an aid to Office of Civil Defense personnel and state CD planners with the responsibility for assessing the operational capability of community fallout shelter systems. The instrument is designed to be applicable in evaluating systems which vary across a wide range in parameters, such as community size and shelter types. It can also be used to evaluate shelter systems in all stages of development from a completely "paper" system to one which is fully operational.

Guidance Material. In addition to the Evaluation Instrument, A Workbook For Use by Local Civil Defense Officials was developed. The workbook utilizes all the basic plan factor information that went into the preparation of the Evaluation Instrument, presenting it in an expanded form amenable to its use as guidance material in the development of community shelter systems.

The guidance material, as presented, is expected to make several important contributions. First, it provides under one cover a condensed and readable listing of the multitude of specific factors which must be considered when developing a community shelter system. Second, the material is presented in such a way that if directions for using it are followed, most of the basic decisions necessary in the development of a shelter system will have been made. And third, guidance in shelter system development is provided in "extra-shelter" areas which have received little attention in the past.

Suggestions for Future Research

The Evaluation Instrument developed during the course of this study is capable of assessing the shelter system planning efforts which have been carried out to date and those which can be expected for some time to come. The guidance material prepared during the study is directed at fulfilling a perceived need for an integrated presentation of the basic data needed to plan a community shelter system. They represent initial efforts in both these areas.

As the results of current and future research on specific aspects of civil defense become available, they should be incorporated into revisions of the guidance material and the evaluation instrument to enhance their usefulness. Suggestions regarding how this might be accomplished on an interim basis may be found in Appendix C.

Several additional areas of guidance and evaluation should also be researched. Among these are the specific efforts listed below. They are discussed in greater detail in the future research section of this report.

1. More definitive levels of adequacy should be determined for plan factors.

2. The effects of plan factor interactions should be determined and a means of evaluating such interactions developed and incorporated into the total shelter system evaluation scheme.
3. An intensive study should be conducted to identify the critical aspects of "extra-shelter" functions of the shelter systems, such as post-shelter planning.
4. Present and future research such as suggested in 3 above should be incorporated into a comprehensive guidance "package" which would outline in detail the consecutive steps required to develop a community shelter system.

EVALUATION INSTRUMENT

Development

This section of the report describes, in turn, the series of steps taken in the total process of developing the evaluation instrument. For convenience, each major step in the process is given an indented sub-heading.

Identification and Organization of Plan Factors. The first step in the development of the Evaluation Instrument was to identify those factors which are characteristics of an effective shelter system. During the initial phases of this task, three general guidelines were evolved to give direction to the effort.

First, a generally stated objective for community shelter systems was prepared. It read as follows: "The purpose of a community shelter program is to protect the people of that community by preserving their respective capacities to a degree which will enable them to survive an enemy attack and return to near normal capacity for productivity in the shortest possible time." From this standpoint, not only specific sheltering functions but also most life-support functions a community normally provides for its people, excluding obvious luxuries, were candidates for plan factors.

Second, an outline of subject-matter categories and subcategories was prepared to structure the search for relevant plan factors and to help classify the factors as they were identified. New categories were added, and rewording of the original categories was carried out as necessary throughout the process of identifying plan factors. This organizational superstructure for the plan factor data also helped insure a complete and balanced coverage of all aspects of community shelter systems.

Third, in identifying and writing up the plan factors, each factor was made as independent of other factors as possible. When subject-matter overlap occurred, appropriate instructions for coping with its effects were included in the Evaluation Instrument.

Within the framework of these general guidelines, plan factor data were collected by the following means:

1. Searching the literature on civil defense and related areas.
This method of collecting plan factor data was continued until review of additional documents contributed no new plan factors.

2. Reviewing available local civil defense planning documents.
3. Discussing plans and planning efforts with civil defense officials with special emphasis on plan factors. Regional, state, and local civil defense officials in California were contacted regarding any shelter system planning and development activities being undertaken. Several additional planning documents pertaining to community shelter systems were obtained through these contacts.
4. Systematically considering the various aspects of a community shelter system and anticipating the need for plan factors. This approach to identifying plan factors involved the use of a very gross system analysis procedure. Each aspect of a community shelter system was considered in terms of activities or gross tasks necessary to accomplish it. In this way obvious deficiencies in plan factor coverage were spotted and corrected.

When no new plan factors were identified as additional documents were searched, emphasis was shifted to editing the plan factor data which had been collected. Each plan factor was reviewed to correct for: (a) redundancy among items, (b) partial subject-matter overlap among items, (c) errors in subject-matter classification, (d) lack of clarity and conciseness, (e) too coarse a categorization, and (f) failure to provide a basis for evaluation.

This editing of items was completed before the items were submitted to judges for the purpose of developing a criticality rating for each item.

Compilation of Standards Information. Concurrent with identifying plan factors, data were collected which could be used as standards against which the evaluator could judge the provisions made for the plan factors by the community whose shelter system was being evaluated.

It has already been shown why all-or-none estimates of the provisions made for plan factors are necessary during an evaluation. In addition, little CD literature, experimental or otherwise, was available to help set standards for giving all-or-none credit for each item. However, a tryout of the evaluation instrument subsequently developed indicated that the evaluation of provisions for plan factors on a present-absent basis was feasible until additional research yields more complete standards data.

In light of the type of standards information available and the fact that a dichotomous (present-absent) evaluation of each plan factor was practicable, standards for the plan factors were handled as follows:

- a) When the standard was subjective in nature, the plan factor was written to include the standard. Objective or quantitative standards data which could be expressed in a short phrase were also incorporated into the appropriate plan factors.
- b) Where quantitative standards information was available but not amenable to inclusion in the plan factor statement, it was presented below the factor to which it pertained and identified as a standard.

Format. Basic decisions regarding the format of the Evaluation Instrument were made early in its development. When it became evident that approximately 500 separate plan factors would be needed in a comprehensive instrument, a checklist type format was deemed the most feasible way of presenting the data. The subject-matter groupings (categories) of plan factors utilized during the process of identifying plan factors were maintained as a means of organizing the factors within the Evaluation Instrument. When appropriate, subcategories were also identified to enhance the usability of the instrument.

Plan factor categories are not specifically arranged according to any definable phases of a national emergency such as pre-attack, attack, post-attack, recovery. The primary reason for this is that the specific plan factors under each category describe activities which should be accomplished in the development and maintenance of a shelter system long before an emergency exists. However, some factors, although having a common subject-matter background, are pertinent either to "pre-emergency" phases of shelter system development, or to actual shelter operation, but not to both. In these cases, two categories are used, and supplementary labels of "pre-emergency" and "in-shelter" are applied. Examples of this situation are Shelter Management and Post-Shelter Planning.

A complete list of all categories used in the Evaluation Instrument is provided below. Definitions as such are not provided because the categories are operationally defined by the factors they contain.

GENERAL	WATER
OPERATIONAL PLAN	FOOD
PLAN/COMMUNITY COMPATIBILITY	SLEEP
POPULATION INDOCTRINATION AND TRAINING	SANITATION
SHELTER ASSIGNMENTS	MEDICAL
SHELTER MANAGEMENT (Pre-Emergency)	SPACE-VOLUME REQUIREMENTS
SHELTER STOCKING	LIGHTING
SHELTER DESIGN	POWER SUPPLY
SHELTER UTILIZATION PLAN	CONTINGENCY PLANNING
PERIODIC MAINTENANCE	COMMUNICATION
POST-SHELTER PLANNING (Pre-Emergency)	CONTROL
COORDINATION	MAINTENANCE
WARNING SYSTEM	NOISE
INGRESS	TRAINING
RADIOLOGICAL DEFENSE	RECREATION AND RELIGIOUS ACTIVITIES
SHELTER MANAGEMENT (In-Shelter)	POST-SHELTER PLANNING (In-Shelter)
ATMOSPHERE CONTROL	

In keeping with the checklist format of the Evaluation Instrument, individual plan factor items are presented in the form of questions. Three possible responses are provided for each item. They are: "not applicable" if the particular factor does not apply to the system under evaluation; "yes" if the factor has been provided for; and "no" if it has not. The symbols N/A and Y are used for "not applicable" and "yes," respectively. A number representing the item weight is used to indicate the "no" response. The reasons for assigning the item weight to a "no" response rather than to a "yes" response are explained later.

All plan factor items except those strictly related to planning functions are stated in future tense. This was done to enhance the flexibility of the Evaluation Instrument. By a simple shift in the verb tense of appropriate plan factors, the instrument can be applied to a shelter system in any stage of development (e.g., preliminary planning, detailed or advanced planning, developmental, operational). Then too, most of the shelter systems to be evaluated for some time to come will be in the planning phases of development. Thus, future tense usage is most appropriate for the present Evaluation Instrument.

Estimation of Plan Factor Criticality. Several methods of obtaining a quantitative measure of shelter system effectiveness were considered during the course of the study. Basic to all was the procedure of rating each plan factor according to the probable consequence or effect of its absence from the system.

One approach which appeared to have considerable promise early in the study involved the use of consequence areas as a means of classifying and ultimately quantifying the effect of not providing for each plan factor. Examples of consequence areas were death or extreme debilitation, danger to physical health, and mental or emotional strain.

A preliminary set of consequence areas was derived, and an attempt was made to classify the plan factors. Problems which defeated the use of this approach were:

- a) The fact that the absence of many of the plan factors could be classified as having several consequences.
- b) In attempting to refine the consequence areas to be more specific, the number of consequence areas approached the number of plan factors.

When initial attempts at specific classification of plan factor consequences failed, a more general classification schema was derived, and the approach ultimately used to obtain quantitative measures was developed. Three major objectives of the approach were:

- 1) To provide a quantitative basis for further development of a scoring method for the Evaluation Instrument.
- 2) To determine whether plan factor criticality is affected by the conditions under which a shelter system operates.
- 3) To obtain information useful in the further screening of plan factors to be included in the final form of the Evaluation Instrument.

Briefly, the steps taken in developing criticality ratings for the plan factors were as follows:

1. A total of 493 plan factor items were assembled in a data collection form. A sample page from the form is shown in Figure 4, Appendix A. Item format and arrangement in the data collection form were nearly identical to those used in the final version of the Evaluation Instrument.

2. A system objective was formulated and four levels of criticality were defined. The system objective served as a criterion against which the level of criticality of individual plan factors could be judged. Each of the four levels of criticality was assigned a weight (3, 2, 1, and 0, respectively, from most to least critical). The system objective and criticality levels, along with the instructions to the raters regarding their use, are shown in Figure 1, Appendix A.

3. Two "conditions" were described under which the criticality ratings were to be assigned. Condition 1 described an urban community with a highly developed industrial complex located near prime targets. Condition 2 described a rural community a considerable distance from prime targets and subject only to fallout. These two conditions were meant to describe points near opposite ends of a continuum of possible conditions under which shelter systems would have to operate. Detailed descriptions of the two conditions are presented in Figures 2 and 3 in Appendix A.

4. A total of thirteen (13) judges rated the criticality of the plan factors. Six (6) raters performed the rating task under Condition 1, and seven (7) rated the factors under Condition 2.

5. An analysis of the rating data was conducted to determine if significantly different levels of criticality were assigned to the same plan factors under the two widely differing conditions. A brief summary of the results of the analysis will be presented at this time. A more detailed discussion of the analysis may be found in Appendix B.

As might be expected, rater bias towards consistently high or low ratings was encountered. To correct for this, the raw rating scores of 3, 2, 1 and 0 were converted to standard scores for each rater. Mean standard score ratings and standard deviations were calculated for individual factors under conditions 1 and 2. "Student's" t test comparisons were made on each factor to determine if the mean criticality ratings under the two conditions were significantly different. None of the factors were rated significantly different at the .01 level under the two conditions. As a further check, the raw score patterns of the ratings on each factor were compared using Fisher's Exact Probability Test¹. Again, no signifi-

1. Siegel, Sidney. Nonparametric Statistics For the Behavioral Sciences. New York: McGraw-Hill Book Company, Inc., 1956.

cant differences were found at the .01 level. The exceptions to these findings were seven items where the instructions to the raters made a significant difference inevitable.

These findings indicated that plan factor criticality should not be affected by the conditions under which shelter systems operate. This meant that the Evaluation Instrument could be applied to shelter systems varying across a wide range of conditions, using a single set of weights for the plan factor items. The alternative would have been a complicated set of varying item weights to match varying shelter system conditions.

Since the ratings under conditions 1 and 2 were not significantly different, a mean standard score rating was calculated for each factor, using the criticality rating data from all thirteen raters. This provided the needed quantitative data for development of the scoring method for the Evaluation Instrument.

Six (6) plan factor items were deleted from the final form of the Evaluation Instrument as a result of receiving a zero (0) rating by all thirteen raters. By definition, these factors were contributing nothing to shelter system effectiveness.

In retrospect, it should be noted that some pre-selection of plan factors took place during the plan factor identification phase of the study. That is, factors of a luxury nature, or those obviously not important, were excluded from consideration. Even so, a normal distribution of plan factor criticality was expected and obtained. A frequency distribution of mean standard score ratings for the plan factors, as shown in Figure 6, Appendix B, illustrates this. Those items at the lower end of the distribution were retained in the Evaluation Instrument because it was felt that at this point in the development of shelter system evaluation techniques, errors of inclusion rather than exclusion were more prudent. To compensate, adequate allowances for differences in relative importance among plan factors were made in the scoring method.

Scoring method. As a prelude to the actual development of a scoring method for the Evaluation Instrument, objectives which the scoring method should accomplish were outlined. These objectives are presented below:

1. Shelter systems should not be penalized when factors not applicable to them are omitted.

2. The scoring method should provide a numerical translation of a shelter system's operational capability with respect to each category of plan factors.
3. Plan factors whose importance to the operational capability of a shelter system was judged to be very high must have a weight which reflects this importance.
4. Providing for less important plan factors must not be allowed to equate for the absence of a highly critical factor if such absence could lead to system failure.
5. Failure to provide for factors whose omission could result in system failure should be penalized heavily by the scoring method.

With these objectives in mind, the scoring method to be discussed was developed.

To preclude penalizing shelter systems for not providing for plan factors invalidated by specific conditions, possible responses to each plan factor item include "not applicable." An N/A or "not applicable" response to a given plan factor item may be appropriate for several reasons. The use of this response choice is discussed in detail later on in Appendix C when utilization of the Evaluation Instrument is reviewed.

Throughout the development of the Evaluation Instrument, the basic structure of the scoring method was under consideration. The choice was between (a) deriving a single overall score to represent a shelter system's operational capability, or (b) developing a profile scoring method whereby the level of operational capability or effectiveness could be presented by plan factor category. The second method was chosen because it facilitates a diagnostic approach to shelter system evaluation. Emphasis on the diagnostic approach to shelter system appraisal is a salient characteristic of the Evaluation Instrument.

In the scoring method developed, a score is computed for each plan factor category. These scores are then displayed graphically on a profile chart. Presentation of the scores in this manner affords an easily interpreted illustration of the strong and weak points of a shelter system. An example of how the profile chart is used is shown in Figure 8 in Appendix C.

Two measures were taken to reflect the importance of highly critical factors, and to prevent the provision for less important factors from

obscuring the absence of a highly critical factor. One, a curvilinear transformation was used in converting the mean standard score criticality ratings of the plan factors to item weights. And two, a scoring technique was developed whereby the plan factor item weights are subtracted from a maximum possible score for the pertinent category when plan factors are not provided for. The combined result is a scoring technique which allows the drastic effect of failing to provide for very important plan factors to be reflected numerically without giving undue weight to less important factors. The shape of the curve described by the transformation chosen to convert ratings to item weights is shown in Figure 7, Appendix B. A discussion of the rationale behind the choice of the transformation accompanies the figure. The conversion table which was used to transform the mean factor ratings to item weights is shown in Table 1, Appendix B.

The maximum score possible in each category was arbitrarily set at 100. Those factors assigned a criticality rating of 3 (absence could cause system failure) by 92% or more of the raters were given an item weight of 100. Items given nearly this high a composite rating received correspondingly high weights (92, 81, 70, etc.) with item weights decreasing rapidly for lower rated factors (see Table 1, Appendix B). Using the scoring method developed, the following situations could occur during an evaluation.

If a factor with an item weight of 100 is omitted, the highest possible score for the category containing that factor is zero (0). The system has failed regardless of how many other factors in the category have been provided for. If a category contains several highly critical factors which have not been provided for, the category would receive a high negative score. Although a shelter system can only fail once, so to speak, negative category scores indicate a serious deficiency in the system with respect to those categories. The larger the negative score, the more serious the deficiencies.

Detailed instructions for implementing the scoring method are provided in the Instruction Manual which accompanies the Evaluation Instrument.

Profile Chart. As previously stated, the evaluation of a community shelter system is diagnostic in nature. That is, an evaluation is conducted to determine, first, if there are deficiencies in a shelter system, and second, where exactly these deficiencies exist. Although information regarding system deficiencies is available piecemeal during the course of an

evaluation, data of this nature are most meaningful when displayed graphically as an integrated whole. The profile chart developed to compliment the scoring method provides a pictorial overview of a shelter system's operational capability. A sample of a completed profile chart is shown in Figure 8, Appendix C.

A bar graph format was chosen for the profile chart because it provides the best contrast between well-provided for and deficient categories. The area assigned to each category is identified by the category title at the top of the chart. Positive converted scores for each category are plotted directly on the chart using the 0-100 scale on the side of the chart. This is not a percentage scale. Rather, it is a unit scale of arbitrary length determined during the development of the scoring method. Negative converted scores are given a token shaded area below the zero line and the actual negative score is entered in the category's area directly below the shaded portion. Token shaded areas and actual scores are used to indicate negative converted scores on the chart because of the extreme variation in possible negative scores. Negative converted scores can range from zero to over 700; this range cannot conveniently be plotted to scale on a small page.

Tryout

At this point in the study a complete but untried Evaluation Instrument existed. The tryout consisted of evaluating two shelter plans by use of the Evaluation Instrument. The following paragraphs tell why a tryout phase was needed and how it was carried out. Specific objectives to be achieved by the tryout are listed. The results of the tryout are discussed in terms of the degree to which each objective was achieved. Also included is a discussion of the deficient categories common to both of the shelter system plans used in the tryout.

Purpose. The purpose of this phase of the study was to proof-test the Evaluation Instrument as developed and make any refinements necessary. Although the two available shelter system documents could only be classified as representing preliminary planning efforts, they were for the most part fairly detailed in nature. A satisfactory verification of the Evaluation Instrument was deemed possible.

Approach. The Evaluation Instrument was applied to two sets of community shelter system planning documents which represented preliminary planning-stage data. The techniques used were exactly as described in the Instruction Manual which accompanies the Evaluation Instrument.

Specific objectives of the tryout were to:

1. Evaluate plan factor items for clarity and conciseness.
2. Test the facility with which individual items could be applied to actual plans.
3. Determine the feasibility of the Evaluation Instrument format.
4. Check the adequacy of coverage of (a) plan factors within the categories, and (b) the categories themselves.
5. Evaluate the scoring method.
6. Evaluate the usefulness of the instrument in assessing the operational capabilities of shelter systems as they are described in written form.
7. Determine, if possible, whether written system documentation is an adequate basis for an evaluation or whether site visits may also be required.

Successful achievement of the above objectives would produce a complete and verified Evaluation Instrument.

Results. Individual plan factor items were evaluated for clarity and conciseness by the thirteen raters during the criticality rating phase of developing the Evaluation Instrument. Ambiguous or vague statements brought to light at that time were re-written. A second evaluation of clarity and conciseness during the tryout served to double-check these aspects of the plan factor items.

Statements regarding provisions for individual plan factors in the system documentation were readily identified with the corresponding plan factor items in the Evaluation Instrument. The only problems encountered were in locating the appropriate information in the planning documents. Further discussion of this situation is pertinent to instrument format which is covered next.

Organization of the plan factor items into subject-matter categories did much to alleviate the problem of matching plan factor items to statements regarding provisions for them in the system documentation. At the

present time, the classification of information and its organization in documents describing a shelter system are determined by the local shelter system planners. As long as this situation continues, the best organizational format for an evaluation instrument is one which facilitates the matching of plan factor items and statements regarding provisions for them. The subject-matter grouping of plan factor items used in the Evaluation Instrument does facilitate this matching process. In the long run, communities should be provided an outline of the Evaluation Instrument so that planning documents would be more standard in organization.

No individual plan factors or categories of factors were found in the two shelter system planning documents evaluated which were not also included in the Evaluation Instrument. This is not to say that the list of plan factors in the instrument is so extensive that new factors may never be identified. However, until communities have considerable more guidance in the development of a shelter system than they do at the present time, the coverage provided by the Evaluation Instrument will be quite adequate. As more comprehensive guidance becomes available to local shelter system planners, the Evaluation Instrument should be revised to accurately assess the more sophisticated planning efforts which can be expected.

The method of responding to individual items provided a satisfactory means for recording the results of the item-by-item evaluation. Category total scores were easily determined. The arithmetic of summing item weights to obtain category totals and the calculation of converted scores for each category were easily accomplished within the formats provided.

Evaluation of the two sets of shelter system planning documents verified the instrument's ability to assess preliminary system planning efforts and to clearly differentiate levels of comprehensiveness in such planning. The sample Operational Capability Profile depicted in Figure 8, Appendix C, was prepared using the actual results of the evaluation of the more detailed of the two system planning documents. As can be seen, great variations in providing for factors in the various categories are reflected by the profile chart. This checks well with the author's impression of these variations as he conducted the tryout. Although this particular shelter system did not make a very good showing in the evaluation even though it was the better of the two, it must be remembered that neither of the planning documents was prepared as a final operational plan. They did

serve their purpose, however, in that they were complete enough to allow an evaluation to be accomplished, showing the Evaluation Instrument to be effective in assessing preliminary planning documents. System documentation actually submitted to OCD for evaluation will most probably be much more complete even in the preliminary planning stages.

Due to the type of system documentation available for use during the tryout, an unqualified recommendation regarding the sufficiency of a completely "paper" evaluation of a shelter system, as opposed to on-site visits, cannot be made at this time. A great deal will depend upon how well all aspects of the community shelter system to be evaluated are documented. Intuitively, it would seem that if a shelter system were completely documented, a satisfactory "paper" evaluation of that system should be possible. However, this assumption should be verified as soon as system documentation and corresponding equipment and facilities are available in an operational community shelter system.

It is also interesting to note the results of the tryout in terms of the deficient categories (those with negative scores) common to both community shelter systems. In general, they represent those areas of civil defense research and guidance which have received the least attention to date. The categories are listed below with comments, where appropriate.

Shelter Management (Pre-Emergency) - particularly deficient with respect to personnel selection, proof-testing, specific assignment to shelters, documentation of management guides, and training.

Shelter stocking - Very little, if anything, was mentioned regarding this. Apparently communities are content to leave this in the hands of the Federal government under the marking and stocking program.

Periodic Maintenance - almost completely ignored.

Post-Shelter Planning (both Pre-Emergency and In-Shelter) - These two categories were completely ignored with the exception of a few comments regarding immediate area decontamination in one of the documents. It should be re-emphasized, however, that the documents evaluated represented such an early stage in shelter system development that the authors may well have felt this was looking too far ahead.

Warning System - Neither plan mentioned a civil defense warning system although both communities probably have them. Perhaps communities consider their warning systems as independent of the shelter system.

Radiological Defense - Both systems were weak in this category although each had provided for factors the other had not.

Sanitation - For the most part, the deficiencies were caused by not providing for several moderately critical factors.

Contingency Planning - As with Sanitation, system failure would be attributed to failure to provide for moderately critical factors.

Conclusions

The Evaluation Instrument developed under this contract represents an initial step in the evolution of a technique for assessing shelter systems. The study has resulted in a first approximation to a comprehensive, objective, and detailed procedure for making a quantitative evaluation of all phases of the development, maintenance, and operation of community fallout shelter systems.

In its current stage of development, the instrument represents composite judgments concerning the essential characteristics of shelter systems, the relative importance of these characteristics to operational capability, and the applicability of the instrument as it is. Civil defense, however, is a dynamic undertaking. In the present instrument, plan factor coverage, and evaluative techniques are as comprehensive and objective as funds and time would permit. Unfortunately, in documenting anything as dynamic as the subject-matter at hand, written material is often in error or otherwise deficient before it can be published. For these reasons, the Evaluation Instrument should be continually updated to reflect the latest results of on-going research.

Since this has been a developmental effort, recommendations in the usual sense of the word are not in order. However, several suggestions with respect to refining the present instrument are appropriate. These may be found in the section of this report dealing with suggestions for future research.

GUIDANCE MATERIAL

Development

Rationale. Adaptation of basic plan factor information to a guidance material format was proposed for several reasons. First, there was nothing resembling the proposed effort available in the literature reviewed. That is, nowhere did there exist a comprehensive yet condensed and readable listing of the multitude of specific factors which must be considered when developing a community fallout shelter system.

Second, it was felt that merely listing the characteristics of an effective shelter system was not enough. Plan factor information should be presented on a concrete level so that decisions could easily be made regarding whether or not factors would be provided for. Further, the format for presenting guidance material should be such that these decisions had to be made.

Third, the amount, type, and level of community shelter system development efforts being carried out in the nation at the time this study began indicated a real need for system-oriented guidance of the type proposed. And fourth, community shelter systems patterned after the proposed guidance material should provide adequate fallout protection, and should be amenable to evaluation by the instrument under development.

Source of Material. The Evaluation Instrument and the guidance material were developed on the basis of the same data. During that phase of the study in which plan factors were being identified in the civil defense and related literature, information regarding the factors was abstracted in considerably greater detail than was necessary for use in the Evaluation Instrument alone. Considerable editing was required to convert these basic data to plan factor items for the Evaluation Instrument. However, much material not needed for the Evaluation Instrument was useful in preparing the guidance document.

In treating plan factors in the guidance material, details and qualifications were woven into the discussion of the basic factors in such a way as to lend continuity to the presentation of the material, and to make it specific enough so that individual local civil defense planners

could relate it to their own situations. The common source of background material made it possible to develop two research products with considerably greater scope than would otherwise have been possible.

Format. Development of a format for the guidance material was based on the following objectives.

1. Discussion of the plan factors had to be readable, reasonably brief, and meaningful to local civil defense planners coping with widely varying system conditions.
2. The guidance material had to be presented in such a manner that basic decisions regarding a shelter system for the community would be made automatically if the instructions for its use were followed.
3. The format must provide for exceptions to community-level decisions with respect to individual shelters.

To accomplish these objectives, A Workbook For Use by Local Civil Defense Officials was developed. The guidance material is presented in a columnar format in the workbook. In the first column from the left, a brief paragraph is devoted to the discussion of each plan factor in turn. Organization of this material within the workbook in general parallels that of the Evaluation Instrument, except where some deviation is needed to achieve continuity of discussion.

Accompanying the discussion of each plan factor and directly to its right in the second column of the format is a decision statement which briefly summarizes the discussion and presents it in the form of a decision. This column is entitled "Decisions for Community Shelter System." For example, a plan factor concerning the cross-training of shelter management personnel is accompanied by the following decision statement: "Members of each shelter-management staff will be cross-trained so that they can substitute, if necessary, for people in other departments." The decision statement is accepted or rejected for the shelter system. When appropriate, decision statements contain blanks to be filled in by the planners. An example of this would be a decision statement such as the following:

"Shelter will be provided for (X) days."

In order to provide for exceptions to community-level decisions with respect to individual shelters, a third column is provided. It is labelled "Modifications for Shelter No. ." Exceptions to or details of the

community-level decision as it relates to a specific shelter are entered in this column. Blank space is provided in the column for recording exceptions. When details specific to each shelter are required, a decision statement with appropriate blanks is placed in the third column. (Example: Shelter No. _____ will provide shelter for (X) days.)

Use

The guidance material workbook was designed specifically for use by local civil defense planners. It is being submitted to the Office of Civil Defense in manuscript form. The workbook represents a proposed approach to a perceived need for guidance in community shelter system development in an integrated form under one cover. If the approach is acceptable, it is expected that OCD will adapt the material to their publication specifications and make copies available to local civil defense officials.

Detailed instructions for applying the guidance material in developing a community shelter system are provided in the workbook. In general, the guidance material is used in two stages. First, decisions are made on the plan factors as they pertain to the shelter system as a whole. Then after appropriate action has been taken, each decision is reviewed in light of individual shelter requirements. This procedure has the advantage of developing a shelter system tailor-made to the facilities available or anticipated. It also serves to double-check the practicality of system-level decisions. If too many individual shelters must make exceptions to a system decision, it may indicate the initial decision was erroneous.

When community planners have read and responded appropriately in completing the workbook, most of the decisions basic to the development of a community fallout shelter system will have been made. This represents the first step in the development of an effective shelter system. Subsequent steps will be concerned with implementing these decisions.

SUGGESTIONS FOR FUTURE RESEARCH

The suggestions for future research to be offered here are categorized as (a) those pertinent to both guidance and evaluation, (b) those specific to guidance material, and (c) those specific to the Evaluation Instrument. They are discussed in this order below.

Increasing Coverage of Critical Aspects of Shelter Systems

Since the scope of the present project is broader than that typical of most shelter research projects, it is not surprising that available literature failed to provide the assistance needed in dealing with all critical aspects of developing, maintaining, and operating a community shelter system. Research efforts to date have for the most part been concerned with those aspects pertaining to a single shelter during the time it is in use as a shelter. Such areas as periodic maintenance, planning for post-shelter living, integrated control of a system of shelters, and coordination with higher echelon CD organizations have received less research attention. As the basic orientation of this study was "evaluation in the light of current and developing knowledge in civil defense," it was possible to identify plan factors in the above-mentioned areas only to the extent that usable information on the subjects was available.

While there were some data available on the critical aspects of what might be termed the "extra-shelter" functions, coverage was not considered to be entirely adequate. Similarly, there was very little such information available to communities as guidance material. This was apparent in the results of the tryout of the Evaluation Instrument. Additional research in identifying the critical aspects of such areas as post-shelter planning, periodic maintenance, coordination, control, etc., is needed to enhance both guidance and evaluation.

Integrating Guidance Material

During the course of the present study, it became apparent that an integrated presentation of the basic data necessary to plan a community shelter system was needed. Although there is a considerable amount of data available at present which is of value to persons trying to develop a community shelter system, this information is scattered throughout a

great number of documents which often disagree on many points. The manuscript, A Workbook For Use by Local Civil Defense Officials, prepared during the present study, represents a proposed approach for bringing this information together in an integrated form under one cover.

The guidance document prepared during the present study represents an initial step in what could be the development of an integrated guide to community shelter system development. Such a guidance "package" would present a detailed, step-by-step set of directions for developing, maintaining, and operating a community shelter system. Achieving an integrated guidance "package" of the magnitude and comprehensiveness suggested will entail; (a) refining present data, (b) increasing the coverage of critical aspects, (c) research on the optimum organization of the guidance material, and (d) research on the format for presenting the data.

Enhancing the Evaluation Instrument

Although work on the present project to date did not reveal any gaps in coverage of important factors as presented in the evaluation instrument developed, continued research may provide information for adding to the plan factors or for revising their weighted values. Other improvements in the instrument may be made possible by future research. These improvements could include the following:

- 1) determination of a continuum or at least multiple levels-of-adequacy for each plan factor.
- 2) development of a means of evaluating the interaction among plan factors.
- 3) refinement of a scoring method incorporating the results of (a) and (b) above.
- 4) continuous review of the accuracy of the plan factor data.

The aforementioned efforts are discussed in more detail in the following paragraphs.

Determining level-of-adequacy standards for the individual plan factors will be a two-stage operation. First, the multitude of specific findings from current and anticipated shelter research must be reviewed and translated into a form which will facilitate their use in determining levels of adequacy. This will be necessary primarily because neither the research efforts nor reports of the findings are oriented towards such a specific use.

As the research data are translated into standards, the dichotomous (present-absent) approach to evaluating plan factor provisions should be replaced with a system which permits the quantification of each level of adequacy at which individual plan factors can be provided for. When possible, several points on a continuum of possible levels should be identified for the individual plan factor. This should be done to allow for flexibility in determining the minimum level of adequacy, since the minimum will, to some extent, be dependent on community conditions. As a supplement, a set of criteria should be developed which will help evaluators determine the minimum levels of adequacy for each shelter system.

It must be remembered, in conjunction with determining levels of adequacy, that not all plan factor variables are continuous. Many are dichotomous or at most trichotomous. These factors probably would be retained in their present form.

A quantitative investigation of the interaction among plan factors is also needed. Interaction between pairs or small groups of plan factors is subjectively apparent when reading the list of plan factors. However, a quantitative estimate of the effects of plan factor interaction is needed to realize the full potential of an evaluation instrument. Of particular concern, is the effect of interaction on the importance attached to each plan factor. This will entail developing a means of evaluating plan factor interactions and then incorporating the results into the total evaluation schema. Other types of interaction which also must be evaluated include interaction among plan factors, community characteristics, and the basic assumptions upon which development of the shelter system is based.

As information becomes available regarding levels of adequacy and plan factor interaction, the scoring method for the evaluation instrument will have to be modified considerably. Integrating level-of-adequacy and interaction data on the plan factors into an overall evaluation schema may result in a major modification to item format and possibly to the organization of the evaluation instrument.

A satisfactory marriage of adequacy and interaction data on a purely objective basis will probably not be possible for some time to come. Initial scoring techniques will most likely rely on judgments in much the same way that the present scoring method does.

Keeping plan factor data current will be of primary concern regardless of other research contemplated. The results of current and future civil defense research should, of course, be incorporated into the evaluation instrument as they become available. This should proceed concurrently with similar efforts on the guidance material. More than a simple updating process is involved, however. Although some new factors will be identified, most new data will apply to levels of adequacy in providing for plan factors. When modifying old data or including new information, the following should be considered. Minimum requirements or standards should be stated as such only when they have been substantiated by research and will stand without extensive revision for some time to come. If the data have not been substantiated and are subject to change, they should be identified as such. This is an important consideration for both evaluation and guidance material. The credibility of minimum requirements and standards information is rightfully suspect when they are subject to continual change without notice.

APPENDIX A: DATA COLLECTION

INTRODUCTION

In this portion of the research report, sample pages of the instrument used to collect criticality rating data are presented.

The first illustration presents instructions that preceded both versions of the plan factor criticality data collection form. Following this, are the two descriptions of the conditions under which the criticality of the plan factors was to be rated. The last illustration in this section represents a sample page of plan factors from the data collection form.

CRITICALITY RATING FORM

As part of Project C-98's effort to develop an instrument which may be used to evaluate the effectiveness of community shelter systems, the plan factors which appear on the following pages have been collected from many sources. Some of the factors are obviously crucial to a system's meeting its objectives; other factors are less important. In order to obtain quantitative estimates of the criticality of the factors, we are asking a number of persons to rate the factors with respect to the consequence of failing to provide for them in planning the shelter system. On the following pages, spaces are provided for you to write a number (3, 2, 1, or 0) beside each factor, which reflects your estimate of the factor's importance in meeting the objective of the shelter system.

A short statement of the system objective, and brief descriptions of the "criticality levels" associated with each of the four points on the scale are given here:

SYSTEM OBJECTIVE

Survival of the greatest percentage of the population possible, with the survivors in condition to commence recovery operations immediately upon leaving the shelters.

LEVELS OF CRITICALITY

Rating	Consequence
3	Failure to provide adequately for this factor could result in the shelter system's failing to accomplish its objective.
2	Failure to provide adequately for this factor could seriously degrade the effectiveness of the shelter system, but would not result in total system failure.
1	Failure to provide adequately for this factor could moderately degrade the shelter system, but would not seriously impair accomplishment of the system objective.
0	Failure to provide adequately for this factor would probably be of little or no consequence for the system's achieving its objective.

Figure 1. Instruction Sheet from Plan Factor Criticality Data Collection Form

CONDITIONS OF THE SHELTER SYSTEM (1)

The importance of many of the plan factors will vary depending upon such circumstances as population density and proximity to targets. To minimize this problem of "contingent criticality," certain conditions of the shelter system are described below. Read these circumstances carefully and keep them in mind as you rate the importance of the plan factors.

1. The shelter system to be evaluated is that of a large city with a highly concentrated population and an accompanying industrial complex.
2. All types of group shelters (50 or more occupants) which are supported with public funds are included in the city's shelter system, i.e., single-purpose, dual-purpose, and multiple-purpose. The dual- and multiple-purpose shelters include some in which the shelter function is primary and some in which it is not primary. Small group (fewer than 50 persons) and family shelters are not included.
3. Local civil defense planners do not consider the city itself a prime target, but it is bracketed by prime targets within a 50-mile radius so that blast, heat, and heavy concentrations of radiation from fallout can be expected regardless of weather and wind conditions.
4. A warning time of 15 minutes between signal and blast is assumed.
5. Size of weapon and type of burst are not specified, but blast and fire damage is expected to range from moderately heavy to very light across the city depending upon distance from ground zero and upon the type of structure. Radiation levels will vary but all may be considered high enough so that unprotected persons would die of radiation sickness in a very short time.
6. Radiation levels will be such that no one will be able to leave the shelter for the first four days following the attack. Limited recovery operations can be initiated 14 days after the attack.

Figure 2. Description of Condition 1 from Plan Factor Criticality Data Collection Form

CONDITIONS OF THE SHELTER SYSTEM (2)

The importance of many of the plan factors will vary depending upon such circumstances as population density and proximity to targets. To minimize this problem of "contingent criticality," certain conditions of the shelter system are described below. Read these circumstances carefully and keep them in mind as you rate the importance of the plan factors.

1. The shelter system to be evaluated is that of a small town (population below 5,000) with low population concentration and little or no industrial complex.
2. There are several group shelters (50 or more occupants) in the system. Several of the possible types of shelters are represented. Possible types are: single-purpose, dual-purpose (with shelter functions either primary or secondary), and multiple-purpose (with shelter function primary or not primary). These conditions are prescribed to preclude simple solutions such as one-shelter communities, or a homogeneous shelter system.
3. The community is definitely not a prime target and is more than 100 miles distant from anything that might be considered a prime target. However, prime targets are located with relation to the community so that radiation levels from fallout will be such that radiation protection must be provided for the people of the community. There are no specific requirements for blast or heat protection.
4. A minimum of 45 minutes is assumed to be available between the time the warning that the nation is under attack is received and the first traces of fallout begin to arrive.
5. Radiation levels will be such that emergency operations may be conducted outside the shelter two days after the attack and full scale recovery operations can commence 14 days after the attack.

Figure 3. Description of Condition 2 from Plan Factor Criticality Data Collection Form

GENERAL (01)		Rating
1. If permanent and completely adequate shelter facilities are not yet available for everyone in the community, have steps been taken to provide interim shelter facilities?	1.	3
2. Has an analysis of such variables as the proximity of targets, the probable priority of such targets, and the prevailing winds been conducted to determine what effects of a nuclear attack are possible?	2.	2
3. Have specific assumptions been made regarding the type of effects (blast, heat, radiation) for which protection is to be afforded?	3.	2
4. Has the degree of protection which is going to be provided against the effects of a nuclear attack been determined?	4.	3
5. Have civil defense personnel made estimates for physical casualties caused by atomic, biological, and chemical attack, based on local data and information furnished by the Office of Civil Defense?	5.	2
6. Have civil defense personnel made estimates for psychiatric casualties at the rate of one such casualty for every four physical casualties, or less?	6.	1
7. Are plans for highway construction and street improvements to be coordinated with civil defense planning to enhance access to the shelters?	7.	1
8. Are building codes such that it is feasible to include shelter space in new buildings?	8.	3

Figure 4. Sample Page of Items from Plan Factor Criticality Data Collection Form

APPENDIX B: DATA ANALYSIS

INTRODUCTION

This section of the report consists of a more detailed presentation of the data analysis phase of the study. The essential features of the analysis are summarized briefly in the section pertaining to development of the Evaluation Instrument. A discussion of the results and implications of the analysis is also provided in that section.

Specific aspects of the data analysis covered here are: preliminary data processing, (b) the primary analysis phase, and (c) derivation of item weights. The discussions regarding these efforts deal with what was accomplished, and, when not obvious, why the approach was used. Interspersed throughout the discussions are figures illustrating the analysis and results.

PRELIMINARY DATA PROCESSING

The item ratings in each data collection form were tabulated by at least two project staff members. Several checks for omitted ratings or incorrect tallies were made as the raw data were prepared for analysis.

Raw score ratings were entered in a data organization form where they were identified by rater, plan factor item, and category. A frequency distribution matrix of the ratings was also prepared for each rater. Ratings were arranged by criticality level (0, 1, 2, and 3) and category. The frequency distribution matrices made it possible to compare rating patterns across raters and identify those raters exhibiting a constant rating bias.

Several instances of rater bias towards high or low ratings were identified. Since the bias appeared to be independent of the conditions under which the ratings were assigned; it was decided to transform the raw score ratings to standard scores. Utilization of standard scores would equate for rater bias without degrading the usefulness of the ratings. The raw score criticality levels (0, 1, 2, and 3) were converted to standard scores for each rater, using as a basis for the transformation the mean and standard deviation of the rater's frequency distribution.

The mean and standard deviation of any standard score distribution are, by definition, 0 and 1, respectively. However, each rater's distribution of standard score criticality levels was given a mean of 10 to avoid minus scores for the lower criticality levels.

Throughout the remainder of this report, all references to ratings, scores, or data will be to their standard score form unless otherwise stated.

DATA ANALYSIS

The criticality ratings were organized for computer analysis so that all rating data pertinent to a single plan factor item could be placed on one card. A computer program already available was modified slightly to obtain the following information for each factor:

- a) mean ratings and standard deviations for each item under conditions 1 and 2.
- b) a mean and standard deviation for each item based on the combined ratings under both conditions.
- c) a "t" value for each item from the comparison of the mean ratings under the two conditions.

Means and standard deviations were also to be obtained for three anticipated populations of ratings. These were: (a) a population of condition 1 item means for those items found to be rated significantly different under the two conditions; (b) a population of condition 2 item means for the same items, and (c) a population of combined mean ratings for those items not rated significantly different.

The rationale for obtaining the above-mentioned data was as follows. Mean criticality ratings were to be used as the basis for determining weights for the items in the Evaluation Instrument. If the mean rating for an item, under condition 1, was significantly higher than the mean rating under condition 2, the two mean ratings would be kept separate and two sets of weights would be derived for that item. If the mean ratings were not significantly different, all ratings would be utilized in computing a combined mean. This value would then be used in deriving a single item weight. The means and standard deviations for the three anticipated populations (conditions 1 and 2 means, and combined means) would be used in the derivation of three different sets of item weights.

Computation of the means, standard deviations, and the t values was accomplished on a Burroughs 220 computer.

A P value of .01 was set as the level of significance at which the null hypothesis (no difference between ratings under the two conditions) would be rejected. Since only those instances in which the mean rating for condition 1 was greater than that for condition 2 were of interest, the significant t value for a one-tailed test was used.

An examination of the t values showed none of the items to have been rated significantly different in the appropriate direction under the two widely differing conditions. The exceptions to these findings were seven items where the instructions to the raters made a significant difference inevitable. As a double check, Fisher's Exact Probability Test was applied to the raw score rating pattern for each item. Again, the seven items previously mentioned plus two additional items were found to be rated significantly different at the .01 level. Analysis of the subject matter content of the two additional items indicated their significance was a chance occurrence. This was not surprising since at the .01 level, five (5) out of a total of 493 items could be expected to be significant by chance alone. The three raw score patterns which would be significant at the .01 level (P value of .005 for a one-tailed test) are shown below in Figure 5.

CONDITIONS

	High	Low
2	0	7
1	6	0

	High	Low
2	0	7
1	5	1

	High	Low
2	1	6
1	6	0

RATINGS

Figure 5. Significant Distributions of Raw Score Ratings Using the Fisher Exact Probability Test

DERIVATION OF ITEM WEIGHTS

Since no significant differences were found between mean ratings for the two conditions, except as noted, combined mean ratings for the factors could be used to derive a single set of weights for the plan factor items. A frequency distribution of the combined mean ratings for the 493 items is shown in Figure 6. The limits on the mean rating scale depict the lowest possible mean standard score (8.0) an item could receive if all raters assigned the item a raw score rating of 0, and the highest possible score (11.5) if all raters assigned the item a raw score rating of 3. Although individual mean ratings are continuous variables, they are grouped in one-tenth intervals for purposes of preparing the frequency distribution and computing item weights.

Before determining the mechanics for deriving item weights, the following question had to be answered. Should the transformation of mean ratings to weights be straight-line or curvilinear? A positively accelerated curvilinear transformation was chosen for the following reasons:

- a) The scale used as a basis for obtaining criticality data on the plan factors (see Figure 1, Appendix A) exhibited a positively accelerated increase in level of criticality from the low to the high end of the scale.
- b) A positively accelerated curvilinear transformation would result in item weights commensurate with the objectives of the scoring method.

In summary, the pertinent scoring method objectives were:

- factors judged highly critical should have a weight reflecting this importance,
- providing for less important factors should not numerically equate for omitting a highly critical factor whose absence could lead to system failure, and
- heavy penalties for failing to provide for factors whose omission could result in system failure.

An approximation of the transformation chosen $(X - 8.1)^4$, where X represents the mean standard score rating, is illustrated in Figure 7. Actual score transformation was accomplished utilizing the conversion table presented in Table 1. Examination of Table 1 shows that mean ratings below

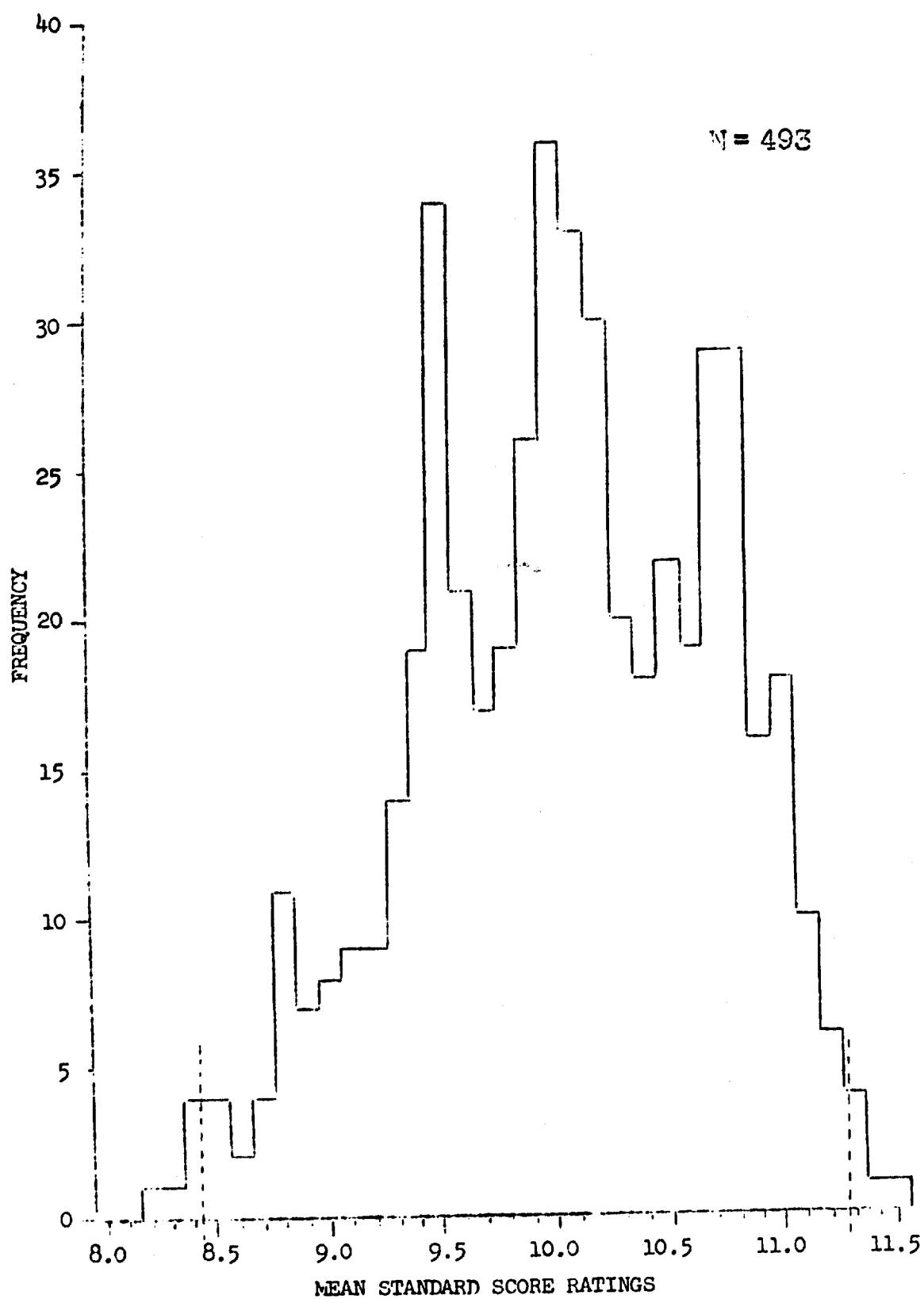


Figure 6. Frequency Distribution of Mean Standard Score Ratings of Plan Factor Criticality Levels

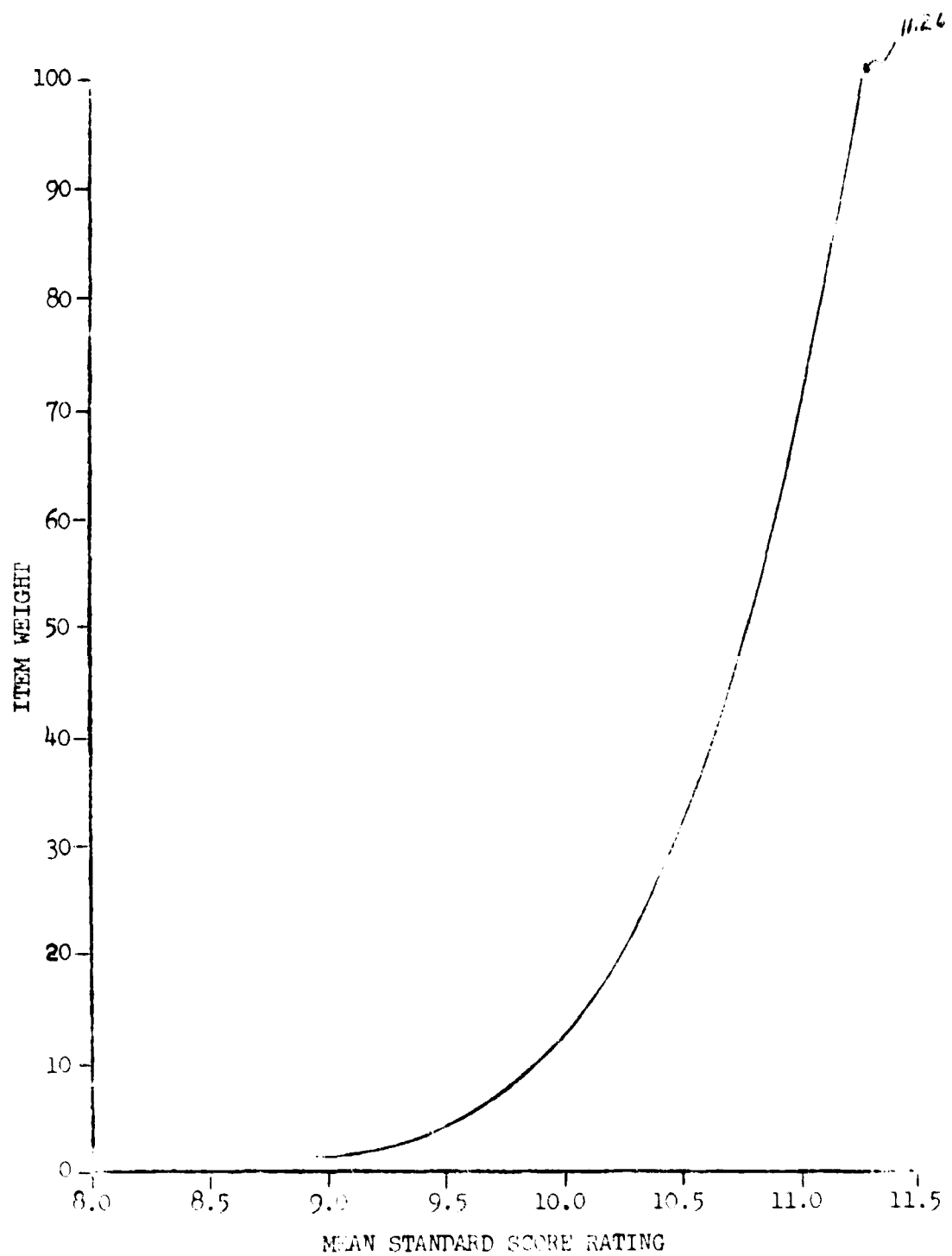


Figure 7. Graphic Presentation of the Transformation of Mean Standard Score Ratings to Item Weights

Table 1. Conversion Table Used in Transforming Mean Standard Score Ratings to Item Weights

Mean Rating	Item Weight	Mean Rating	Item Weight
8.0	0	9.8	8
8.1	0	9.9	10
8.2	0	10.0	13
8.3	0	10.1	16
8.4	0	10.2	19
8.5	1	10.3	23
8.6	1	10.4	28
8.7	1	10.5	33
8.8	1	10.6	39
8.9	1	10.7	45
9.0	1	10.8	53
9.1	1	10.9	61
9.2	1	11.0	70
9.3	2	11.1	81
9.4	3	11.2	92
9.5	4	11.3	100
9.6	5	11.4	100
9.7	6	11.5	100

8.5 received a weight of zero. This meant that the presence or absence of plan factors with a mean criticality rating below 8.5 would have no effect on the operational capability of a shelter system. Six items fitting this description were deleted from the Evaluation Instrument. The mean ratings of these six items are identified on the frequency distribution in Figure 6 by the broken line at the lower end of the distribution separating them from the rest of the scores.

Further examination of Figure 7, particularly with respect to the higher mean ratings, illustrates the effectiveness of the transformation in achieving the desired relationship between ratings and weights.

The decision was made to assign an item weight of 100 to those items whose absence was judged to result in system failure by at least 92% of the raters. When coupled with the other aspects of the scoring method, such a decision meant that omitting a factor so weighted would be indicative of system failure regardless of provisions for other factors in its category. If 92% of the raters gave an item a raw score rating of 3, the minimum standard score possible was 11.26. This value, then, served as the lower limit for mean standard scores which could be assigned a weight of 100. Since an item weight of 100 was equivalent to denoting system failure if the factor were not provided for, mean ratings above 11.26 were restricted to item weights of 100. Mean ratings so weighted are set apart from the other scores plotted in Figure 6 by the broken line at the upper end of the frequency distribution.

APPENDIX C: UTILIZATION OF THE
EVALUATION INSTRUMENT

UTILIZATION OF THE EVALUATION INSTRUMENT

A detailed discussion of the intended use of the Evaluation Instrument is presented in this appendix as a supplement to the discourse on evaluation-instrument development and verification contained in the main body of the report. This section deals with (a) the purpose of conducting a community shelter system evaluation and by whom it should be conducted, (b) evaluation techniques, (c) scoring techniques, (d) preparation and interpretation of profiles, (e) critiquing an evaluation, and (f) updating techniques.

Purpose

As stated earlier in this report, a major goal of this project was to develop an evaluation instrument which could be used to assess the operational capability of community fallout shelter systems. This purpose has been accomplished. The Evaluation Instrument is a fact. Now a more definitive purpose regarding the employment of the Evaluation Instrument is in order. Brief statements of portions of this definitive purpose have appeared elsewhere in this report. They will be reviewed and further discussed here.

First, the Evaluation Instrument is to be used as a diagnostic tool. In this respect, it will be useful in helping fulfill the federal responsibility to know and report the status of civil defense efforts throughout the nation. Results of evaluations can be used to improve shelter systems rather than merely comparing systems as to their adequacy. All aspects of its development have been directed to these ends. Plan factors are numerous (487) and to a considerable degree specific in nature. The scoring method is based on obtaining separate scores for each category as opposed to a single numerical score for the entire shelter system. A profile chart was developed as a means of depicting the adequacies or deficiencies of a shelter system by category. A critique of each evaluation is suggested as a means of presenting the results in a comprehensive form which will be of value to the local civil defense planners concerned in correcting any deficiencies detected.

Second, the Evaluation Instrument is intended for use by Office of Civil Defense personnel at the national, regional and state levels. It is not intended for use by local civil defense officials. People involved in the development of a shelter system for their community cannot be expected to possess the background or the candor necessary to provide a fair and

impartial evaluation of their own shelter system. In the future, it is expected that as shelter systems are developed, plans and descriptions will be submitted to the Office of Civil Defense for evaluation in much the same manner that shelter facility designs are submitted for evaluation and approval at the present time.

Evaluation Technique

As a prelude to the actual evaluation of a shelter system, the following steps should be taken. First, the evaluator should familiarize himself with all material pertinent to the system under evaluation. Second, the material should be classified and organized to parallel the Evaluation Instrument. When the second step is not possible, additional time should be spent on becoming familiar with the organization of the material, including perhaps placing category labels in the margins of the documents. Accomplishing these two preliminary steps will greatly facilitate the evaluation and reduce the possibility of under-evaluating a shelter system by overlooking information pertaining to some of the plan factors.

Item format and its relation to the evaluation technique was discussed previously in relation to other aspects of Evaluation Instrument format. The mechanics of shifting verb tenses as necessary within individual plan factor items is covered in the Instruction Manual. No further discussion on this point is required.

Determining whether or not a specific factor has been provided for can be either a simple or a difficult task. Much depends on the way information on the system is classified and organized. Also, general rather than specific descriptions of how individual factors are provided for will affect the stability of an evaluation. That is, if an evaluator is forced to make inferences as to whether or not factors are provided for because information is stated in too general terms, he may not always make the same decisions, given like amounts of information regarding plan factors. The most equitable solution to this problem is consistency. Type and amount of information which must be available before a factor can be considered as having been provided for should be determined before starting an evaluation. All decisions regarding presence or absence of factors should then be based on these pre-determined guidelines.

An important point to remember when evaluating a shelter system is that decisions regarding plan factor items are trichotomous (present-

absent-not applicable) rather than dichotomous (present-absent). Many plan factors are applicable to all shelter systems regardless of the conditions under which the system functions, but many are not. Several factors may render a particular item not applicable to the system under evaluation. Among these are;

- a) assumptions regarding basic system objectives which preclude the necessity of providing for the factor,
- b) documented or obvious conditions such as proximity to targets, extremely small shelter system in terms of number of shelterees and shelters, etc., and
- c) providing for other factors in such a manner that the factor under consideration is not applicable as stated.

With respect to (a) above, it must be remembered that at least those portions of the community shelter system developed and financed by the community are under its jurisdiction. If assumptions are made regarding these areas which render plan factors not applicable, then as far as that shelter is concerned those factors are not applicable. If conditions are such that the factors should be provided for, this point should be emphasized when critiquing the evaluation. But in scoring the system, the factors in question should be marked "not applicable."

One additional aspect of the evaluation technique should be emphasized. This concerns control items in the Evaluation Instrument. Several of the categories contain items which determine the response to several or all items following them in the category when they are responded to negatively.

The interrelated nature of control items and the items they affect is such that a negative response to a control item makes only a "negative" or "not applicable" response possible for the affected items. For the purpose of scoring the affected items, a "not applicable" response was made mandatory when the relevant control item received a negative response. This was done for two reasons. First, the affected items are in actuality more specific aspects of the control item and are therefore in a very real sense no longer applicable when the control item is answered negatively. Second, there is no practical value in subtracting the weights of these subsidiary items; to do so would, in effect, increase the negative criticality score beyond the value originally assigned based upon the judged effect

of the control item.

Other aspects of the evaluation technique, such as the procedure for marking individual items, are adequately covered in the Instruction Manual; they merit no additional discussion here.

Scoring Technique

Detailed procedures for scoring an evaluation are presented in the Instruction Manual. This discussion is intended to be expletive in nature and useful as a supplement to the procedures outlined.

As previously explained, there are three response choices for each plan factor item in the Evaluation Instrument. They are: "not applicable," "yes," and "no." The symbols used to indicate these responses in the instrument are N/A, Y, and a number representing the item weight. Item weights are used as symbols for a "no" response for two reasons. First, the negative response is the only one given a numerical value in the scoring method. Second, it simplifies the format of the Evaluation Instrument and makes unnecessary a further translation of a "no" response to a numerical value when scoring an evaluation. With this format, it is a simple two-step procedure to obtain a converted score for each category. All item weights in a category which are circled during the evaluation (indicating a negative response) are added together. This sum is then subtracted from the maximum score for the category to obtain the converted score.

Coincident with the negatively oriented scoring procedure is the negative nature of the item weights themselves. That is, they are based on judgments regarding the effect of the failure to provide (or to provide acceptably) for plan factors in a shelter system. Also, the weights are subtracted from a maximum possible score when the corresponding plan factors are not provided for in the shelter system being evaluated. The rationale for this negative approach to system evaluation is based on the scoring method objectives previously outlined. Principally, it is the most effective way of high-lighting shelter system deficiencies.

As previously mentioned, an arbitrary value of 100 was assigned to each category as the maximum possible score a category could achieve. A category receives the maximum score only if all factors in the category are provided for, or those which are not provided for are not applicable to the shelter system being evaluated. For every applicable plan factor not pro-

vided for in a category, an amount equal to the factor's item weight is subtracted from 100.

Since the sum of all item weights in a category is in most cases greater than 100, it is quite possible for a category to have a negative converted score. A zero or negative converted score for a category can occur when one or more factors judged unanimously as causing system failure are not provided for, or in the case of the larger categories when several moderately critical plan factors are not provided for.

In summary, the scoring technique can be likened to a demerit system in which each person starts with a given number of credits or merits. Then a pre-determined number of points are assigned to various negative characteristics, and demerits of corresponding value are charged to individuals for deficiencies such as slovenly appearance, below average performance, etc. In such a system, the best record which can be achieved is to end up with the same number of points originally assigned. Anything less denotes the detection of deficiencies. So it is with the scoring method developed for the Evaluation Instrument.

Profile Chart

Upon completion of the computational steps in scoring an evaluation, a converted score should appear on the Computation Sheet of the Evaluation Instrument booklet for each category. This converted score is plotted on the profile chart provided in the Evaluation Instrument booklet. An example of a completed profile chart is shown in Figure 8.

Because item weights are based upon pooled judgments rather than upon experimental manipulation of operational shelter characteristics, no system failure point has been labelled on the profile chart scale. However, the item weights, maximum score concept, and profile chart scale, have been developed and defined in such a way that a zero or negative converted score in one or more categories is indicative of system failure. Since the Evaluation Instrument is a diagnostic tool, primary concern is for what caused an indication of system failure. Categories deficient to the point of system failure are quite obviously portrayed as such on the profile chart. This is the function of the present profile chart. Identification and discussion of the causal factors and the suggestion of remedial action are the function of the Evaluation Critique.

Evaluation Critique

It is not the purpose of this section to provide a detailed outline of how an evaluation should be critiqued. The special relationship of the Office of Civil Defense (OCD) with state and local civil defense organizations demands that this be determined solely by OCD policy. However, several suggestions are discussed regarding some aspects judged to be important in such a critique as it relates to the evaluation.

The most important point, quite naturally, is that a critique be prepared. No score in a diagnostic evaluation such as this has meaning unless the details of the shelter system to which the score relates are discussed.

Each category score should be discussed in terms of the plan factors which are absent or inadequately provided for. For the critique to be of the most value, it is suggested that detailed guidance also be given on how missing factors can be provided for. If alternative means of providing for factors are available, they should be listed so that communities can choose the means most suitable to their circumstances.

When a category receives a zero or negative score, one or more highly critical factors are usually missing, and the remedial action required is obvious and amenable to discussion. However, interpretation of low positive scores with respect to system failure is a much more complicated task. Since certain combinations of absent factors could result in equal scores but unequal total effects, inspection of the individual factors involved should always be accomplished. If a low positive score is the result of failing to provide for a considerable number of moderate and low criticality factors, suggestions for improving the system may have to be presented in the form of alternative courses of action, particularly when factors which are low in criticality but costly to provide for are involved.

Updating Techniques

The content of plan factors included in the present Evaluation Instrument reflects material in OCD issuances, and in CD research reports available as of the end of November 1962. Inputs to the factors themselves were curtailed at this time to permit the collection of data on the level of criticality

of the individual factors. Civil defense research as an on-going effort, has already produced results which affect the content of the present plan factors.

The extent to which the present population of plan factors represents the total possible number, is not known. However, it is known that coverage is not complete; particularly in what might be termed the "extra-shelter" areas. To further complicate the matter of coverage, no two civil defense "experts" will agree on all factors which should or should not be included in an evaluation instrument; seldom will they agree on the importance of a given factor.

In light of the above-mentioned conditions, the revision of item content, and the addition or deletion of whole items must be feasible and relatively easy in order to maintain a current and acceptable instrument. Three methods of determining item weights for new or substantially revised items are offered in this section. The weighting techniques described herein represent interim measures which are appropriate for a limited number of changes. If large-scale revisions are to be undertaken, efforts should include the development of a more sophisticated scoring method. Some aspects pertinent to refining the present scoring method are outlined in the section of this report dealing with suggestions for future research.

Approach A. The approach outlined here is essentially that used to derive item weights for the present evaluation instrument. It is recommended as the most reliable of the three to be presented. The sequential steps in implementing the approach are outlined below.

1. Obtain ratings regarding the level of criticality of each new or substantially revised item from as many judges as possible who are knowledgeable in the subject-matter areas represented. The raters should be given instructions similar to those shown in Figure 1, Appendix A. The items need not be rated under specific conditions as was done in the present study since it was found that such conditions do not significantly affect the ratings.
2. Compute standard score equivalents for each rater for the four levels of criticality (0, 1, 2, and 3).

3. Sum the standard score ratings across raters for each item. Calculate a mean standard score rating for each item. Round these mean ratings to the nearest tenth (examples: 8.3, 9.7, 10.6, etc.)
4. Calculate a conversion table similar to the one shown in Table 1, Appendix B, using the transformation $(X-K)^4$; X represents the mean standard score rating and K is a constant. The value of the constant should equal the mean standard score rating obtained if all raters assigned an item a raw score rating of 0.
5. Enter the conversion table with the value of the mean standard score rating for the item, and read off the corresponding item weight. Using the transformation suggested in step 4, an item which receives a majority of raw score ratings of 0 will have an item weight of 0. This signifies that the item is judged to have no effect on the operational capability of a system. It should not, therefore, be included in the evaluation instrument.

Approach B. The approach outlined here is a short-cut method for obtaining item weights similar to Approach A. Its use, however, demands acceptance of the assumption that, statistically speaking, the raters to be used to assess the criticality of new items are from the same rater population as those used in judging item criticality for the present evaluation instrument. Accepting this assumption makes unnecessary the (a) computation of a new set of standard scores for each rater, and (b) development of a new conversion table. The steps to be taken in implementing Approach B are as follows.

1. Obtain raw score ratings of item criticality as described in Approach A.
2. Substitute the standard score equivalents given below for each rater's raw score ratings.

<u>Raw Score Levels</u>	<u>Standard Score Equivalents</u>
0	8.0
1	9.2
2	10.4
3	11.5

3. Sum standard score equivalents across raters for each item.
Compute a mean standard score rating for each item. Round the mean standard score ratings to the nearest tenth.
4. Enter the conversion table shown in Table 1, Appendix B, with the mean standard score rating, and read off the corresponding item weight.

Approach C. If the two preceding approaches are not practicable, a third method may be used. However, it is the least desirable of the three from the standpoint of reliability of results. The steps for this approach are outlined below.

1. Compare each new item with other plan factor items of the same subject-matter background.
2. If a comparable item (in terms of judged importance) can be found in the existing instrument, assign the new item the same weight.
3. If a comparable item can not be found, pick out two items; one which appears to be slightly more important than the item under consideration, and the other slightly less important. Assign the new item a weight mid-way between the weights of the two comparison items.

General Comments. Minor changes in item content should not affect item criticality. An example of such a change would be the reduction in the protection factor minimum acceptable in the federal marking and stocking program from 100 to 40. However, when standards or plan factors are altered substantially, the affected factors should be re-evaluated in terms of their relative importance to shelter system operation. It should also be re-emphasized that the above-mentioned approaches to obtaining weights for new items to be added to the present evaluation instrument are acceptable when small numbers of items are involved. Wholesale changes in the content of the instrument should be accompanied by repeating the total weighting procedures used in the present study; such an effort could also include refining the present scoring method.

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